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US ARMY RESEARCH AND DEVELOPMENT GROUP (EUROPE)

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TRIP REPORT

11th Annual ASME
Gas Turbine Conference
Zurich, Switzerland
14 - 17 March 1966

Major Tom H. Brain

EUROPEAN RESEARCH OFFICE

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T R I P R E P O R T

TO: Chief, ERO — 31 March 1966

REPORTING OFFICER: Major Tom H. Brain

CONFERENCE ATTENDED: 11th Annual ASME Gas Turbine Conference
Zurich, Switzerland

DATES: 14 - 17 March 1966

1. The 11th Annual Gas Turbine Conference was sponsored by the Gas Turbine Division of the American Society of Mechanical Engineers with the cooperation of the Swiss Society of Engineers and Architects. The Conference was held between 14 and 17 March 1966 in the Kongress Hall, Zurich, Switzerland. The intent of the ASME Gas Turbine Division was to present a world-wide spectrum of products, components, materials, and technical information vital to the gas turbine industry. 127 authors presented 87 different technical papers in 22 separate technical sessions during the four day period. At the same time, 76 exhibitors from the U.S. and European countries staged a very large display of gas turbine equipment and components. The meeting of over 1,000 American and European engineers marked the first time that ASME has held a regular meeting in Europe.

2. The 87 technical papers were divided into 10 groupings. The 10 session titles were: Large Gas Turbines, Marine, Closed Cycle Gas Turbine Systems, General, Jet Expanders, Combined Cycle, Special Equipment, Metallurgy, Small Gas Turbines, and Noise. All of the sessions were extremely well attended by the conference registrants and, in general, the discussions following each paper usually provided a platform for sharp comments and detailed analyses of the author's work. A complete list of the technical papers is attached to this report as Inclosure 1. Special papers in the Army area of interest are summarized in the following paragraphs. The complete proceedings or individual papers are available through the ASME Order Department, 345 East 47th Street, New York, New York 10017. The cost of each paper is 75 cents to members of ASME and $1.50 to non-members.

3. Many of the papers which were presented are in the U.S. Army area of interest. A brief resume of some of these is presented here.

a. Military Potential of the Small Gas Turbine by D. D. Weidhuner, Chief, Power Section, Hq, USAMC, Washington, D.C. (Paper No. 66-GT-91

(1) This paper presented the U. S. Army program for advancing small gas turbine technology and the benefits to be gained from the program.

3. a. Military Potential of the Small Gas Turbine (cont'd)

Mr. Weidhuner pointed out the performance, weight and volume, and reliability requirements which are being developed in the component technology program. The characteristics which are sought are: (a) Decreased fuel consumption, (b) Reduced size and weight, especially for VTOL aircraft, (c) High component life and reliability, (d) Engine cost must be significantly improved over current turbine engines.

(2) The current state of the programs in the compressor, turbine, and regenerator areas were reviewed as well as the demonstrator engine programs involving the T53 and T63 engines. Mr. Weidhuner mentioned the ATAC regenerative turbine engine for heavy vehicles. The family of industrial engines was discussed. The 20 HP engine award has not yet been made while the 60-90-120 HP engine is in development at Continental. The 200 - 300 HP engine is being developed by AiResearch Division of Garrett Corporation and will be available with or without a recuperator. All of these engines are to be designed with a fixed shaft. The paper concluded with the benefits which would accrue to the Army from these various programs and a statement of the Army's keen interest in gas turbines.

(3) The paper was well received by both the American and European engineers present. A series of questions concerning the paper in the areas of R&D funding, overhaul times, cost of overhaul and the use of the small gas turbine in fixed wing aircraft were dealt with by Mr. Weidhuner in an extremely competent manner.

b. Whither Go the Small Gas Turbines? by Dr. W. T. Von de Nuell, The Garrett Corporation, Los Angeles, Calif (Paper No. 66-GT-90)

Dr. Von der Nuell reviewed the present use of small gas turbines in aircraft, APU, GPO, and starter systems and other conventional applications with a great deal of perception. He discussed the inherent problems, such as high fuel consumption, materials selection to resist corrosion and fouling, and the efforts to move ahead by increasing component efficiency, increasing pressure ratios, using higher gas temperatures and improving part load fuel consumption. He described the relative merits of the Turbomeca Astazou X, the Pratt & Whitney PT6(T74) and the Garrett FPE-33(T76). He predicted that costs would get down to $30/HP eventually. The multispool gas turbine with intercooling and successive heat addition between stages appears to offer the best solution to increase the pressure ratio, permit exhaust heat recovery, and arrive at a good part load fuel economy without, at the same time, going to higher (above 2200° F) turbine temperatures. He also discussed the problems of air filtration, materials and investment casting techniques. In summary, Dr. Von der Nuell predicted that the marked for small gas turbines would grow but not as rapidly as some would like.

c. Problems related to the Development of a Gas Turbine in the 10-30 HP Class by Ulrich Oprecht, Heat, Turbomachines Department, Adolph Saurer, Ltd., Arbon, Switzerland (Paper No. 66-GT-87)

Dr. Oprecht reviewed the inherent problems in designing a shaft-power gas turbine in the 10-30 HP class and discussed his design philosophy. The GT-15 design, with a calculated efficiency at 12%, consists of a radial

3. c. Problems related to the Development of a Gas Turbine in the 10-30 HP Class (cont'd)

turbine. This combustor configuration limits the thermal loading to conservative values. The fuel is admitted through the center of the high speed rotor shaft where it is thrown centrifugally into the combustion chamber. The turbine wheel is overhung and the supporting bearings are fuel cooled. The development was highlighted by a bad shaft bending vibration problem which caused seizures prior to the attainment of full speed (55,000 RPM). After a computer solution, the problem was cured by supporting the inner ball bearing in a built-in squeeze film damped suspension, balancing the rotor according to the second bending critical shape and stiffening the bearing at the intake end of the compressor. The dry engine weight is only 22 lbs. Evaluation tests were accomplished which included hand starting at -40° C on JP1, JP4, and a German winter diesel fuel. Mass flow was 0.45 lb/sec with a fuel consumption of 26 lb/hr. The pressure ratio was 3:1.

d. The Energy Exchanger A New Concept for High Efficiency Gas Turbine Cycles by R. C. Weatherston and A. Hertzberg (Paper No. 66-GT-117)

This paper presents a method of circumventing the turbine inlet temperature limitation of present day gas turbines. The method is based on a direct fluid to fluid energy exchanger whereby the available energy of expansion of the hot combustion gas in a gas turbine cycle is transferred directly to a colder gas. The paper investigates several possible modes of operation for aerodynamic wave processes to determine the inherent limitation in efficiency of direct fluid to fluid energy exchange processes. It was shown that, by using a system of isentropic compression waves to avoid shock losses and by carefully choosing the molecular weights of the fluids utilized in the energy exchanger, perfect energy exchange is possible in principle. When allowances are made for losses due to mixing, leakage, and viscous effects, an energy exchanger utilizing heated combustion air at 3420 F to drive steam at 1500 F with a potential energy exchange efficiency of 85% is feasible. Application of the air-steam energy exchanges operating in gas turbine cycles utilizing a conservation choice of component efficiencies indicate that thermal efficiencies of gas turbine power cycles of 50 - 60% may be possible.

e. Small Gas Turbines in Industrial Applications by Paul A. Pitt, Vice President, Engineering and Research, Solar, San Diego, Calif. (Paper No. 66-GT-110)

(1) Mr. Pitt covered the present uses of gas turbines in the size range of 200 to 1600 HP in the application areas of natural gas pipeline compressors, liquid pipeline pumps, electric power generation, and oil well servicing. The economics and characteristics of the small gas turbine to

include a discussion of durability, low fuel consumption, low maintenance, and good reliability were covered. In the area of reducing production costs, the future outlook is that the first cost of a turbine might be halved. He predicted that with new alloys, e.g., vacuum cast nickel-base alloys, turbine blades need not be cooled in order to raise turbine inlet temperatures. As an example, in long-life turbines which require stress to rupture times of over 100,000 hours in critical hot parts, there is a possibility of increasing turbine inlet temperatures from 1500 F to 1700 F. Additional information is needed on the corrosion, erosion, and age hardening characteristics of these alloys.

(2) In conclusion, Mr. Pitt stated that the primary reason for the gas turbine's ability to compete is not a high thermal efficiency but the virtues of lower first cost, installation cost and operating cost. The adaptability of the small gas turbine to a wide variety of applications is a major factor in attaining a level of production necessary to achieve competitive first cost. The future development of small gas turbines will be concerned with lowering cost and improving performance.

f. The Split Compressor Differential Gas Turbine Engine for Vehicle Propulsion by G. N. Doyle, Clarke, Chapmen & Co., Ltd, Gateshead, Durham, England; and T. S. Wilkinson, C.A. Parsons & Co., Ltd, Newcastle-upon-Tyne, England

The authors discussed a gas turbine which has a low pressure (LP) compressor connected to a high pressure (HP) compressor by an epicyclic differential gear. The HP compressor and the power turbine are on the same shaft. The engine output shaft is one element of the epicyclic gear. When this arrangement is coupled with a heat exchanger, the overall predicted performance would yield a stall torque ratio of 4:1 at a turbine inlet temperature of 1170 deg K. The engine, abreviated SCDGT, would also appear to be competitive in cost to the free power turbine (FPT) since the cost of the LP compressor is balanced by the elimination of the gearbox. The SCDGT is also shown to be superior to the FPT in handling characteristics. Fuel consumption, engine braking, acceleration and starting characteristics were considered and discussed. Acceleration and ease of starting are better in the SCDGT than the FPT. The paper drew many differing comments from the audience and the concept was, in fact, attacked as economically infeasible. The authors, with the aid of Dr. W. Hryniszak, produced logical reasons for their claims of feasibility.

g. <u>The Design and Development of the Orenda OT-4 Gas Turbine</u>
by D. Quan, Chief Project Engineer, Orenda, Division of Hawker Siddeley Canada, Ltd., Toronto (Paper No. 66-GT/M-23

(1) Mr. Quan initially covered the inherent advantages of the gas turbine as: compactness, low weight, low magnetic signature, low noise level, reliability, ease of starting and maintenance, and the multi-fuel capability. The objective of the development program was to retain the advantages aswell as to obtain a 600 HP engine with a s.f.c. of 0.40 lb of fuel per bhp hr. This is equivalent to a thermal efficiency of 34.6%. A variant of the OT-4 known as the AGT-600 is being specifically developed for the US Army. The OT-4 is a simple regenerative cycle, two shaft turbine with a pressure ratio near 4. The lower pressure ratio permits fewer compressor stages (6) and greater blade lengths, which helps to achieve better compressor efficiency. The compressor rotates at 26,800 RPM. There were 4 major development problems with the OT-4. They were poor heat exchanger effectiveness, low turbine efficiencies, high ducting pressure losses and high mechanical losses. The causes of each of these 4 problems were discovered and appropriate changes made. As an example, the original cross flow heat exchangers were changed to counter flow heat exchangers which resulted in a heat exchanger thermal effectiveness of 86.5% versus 75% in the original. The AGT-600 engine is a modified OT-4. The 600 is wider (45 1/2 vs 39 in) and the output speed is 3600 RPM instead of 6000 RPM. The heat exchanger core volume is also smaller with a slight compromise on fuel consumption.

(2) Mr. Quan's comments on the program were:

(a) The two engines and the gas producer test unit in the initial development program were not sufficient to achieve a satisfactory rate of progress.

(b) The design and development time cycle for an advanced non-flying gas turbine is about the same as that of an aircraft gas turbine and is also a function of the turbine inlet temperature levels.

(c) Adequate tooling should be used to insure proper aerodynamic shapes and aerodynamic cleanliness of air passages.

(d) Regenerative engines create additional problems due to the thermal distortions and stresses over non-regenerative engines.

(e) Common sense is required to eliminate instrumentation requirements during testing as soon as practicable.

g. The Design and Development of the Orenda OT-4 Gas Turbine (cont'd)

(3) The OT-4 has a great deal of growth potential. By adding one zero stage, an output of 750 HP can be reached and 900 HP can be obtained by adding two stages. With the development of higher temperature alloys, an increase of 150 deg F in turbine inlet temperature would result in about 15% increase in power. Thus, a 900 HP engine could produce 1050 HP.

h. Among the other fire papers, of note were several which were pertinent:

The Development of a Glass-ceramic Axial-Flow Rotary Regenerator by J. G. Lanning and D. J. S. Wardale. (Paper No. 66-GT-107)

This paper covered the work done at Cercor Products Dept. of Corning Glass on the inexpensive glass-ceramic rotary regenerator. The paper lists the design objectives and properties.

Thrust Augmentation by Dr. W. H. Heiser, Dept. of Mech. Engr's, MIT (Paper No. 66-GT-116)

This paper analyzes from the theoretical and practical views the injection and blade types of thrust augmentation devices. Dr. Heiser develops the theory that bladed thrust augmenters more nearly approach the ideal augmenter and hence should be the object of additional research. Dr. Heiser was most impressive in his presentation and handled the questions nicely.

Special Fluid Power Plants by W. Hrymisok, M. Hutchinson, and A. Renton of Clarke, Chapman and Co., Ltd., Gateshean-upon Tyne, England (Paper No. 66-GT-84)

The authors claim that the shortcomings of the cycles used in the production of power from the energy stored in a fuel are not the fault of the prime mover but are the results of defects in the thermodynamic properties of the working fluid. Investigations were made with fluids, other than air and water, such as trichloromonofluoromethane, and the effects on cycle efficiency and components performing in the cycle were considered. The results demonstrated that, for application in the Rankine cycle, special fluids do exist which would be used as the working medium.

4. CONCLUSION:

Almost all of the technical papers were pertinent to the U. S. Army area of interest. The intent in this report is to review those which were especially interesting. The exclusion of other papers does not imply that they were unimportant.

The conference was well attended by European engineers and scientists. The presence in Europe, for a brief time, of some of the top leaders in the gas turbine industry was certainly stimulating. The degree of participation by European scientists and engineers in the technical discussions was excellent. The incisiveness of their comments on the technical content of papers came as a surprise to many American authors.

TOM H. BRAIN
Major, GS
Executive Officer

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List of Technical Papers Presented
at the ASME 11th Annual Gas Turbine Conference
Zurich, Switzerland, 13 - 17 March 1966

1. <u>Large Gas Turbines</u>

   a. 100,000 Hours With Gas Turbines/ Paper No. 66-GT-88
      Alexander H. Carameros

   b. Long Life Base Load Service at 1600° F Turbine Inlet Temperature/
      Paper No. 66-GT-98 - Neal E. Starkey

   c. 10,000,000 Hours of Gas Turbine Operation/ Paper No. 66-GT-109
      George R. Kennedy

   d. Experience Gained From a Ten-Year Operating Gas Turbine Working
      With Blast Furnace Gas/ Paper No. 66-GT-97

   e. Electric Utility Gas Turbines - A Maintenance Report/ Paper No.
      66-GT-100 - O. H. Pfersdorff

   f. 15 Years of Gasturbine ~~Operation in Venezuela's Industry and~~
      Utilities/ Paper No. 66-GT-103

   g. Availability Balance of Gas Turbines/ Paper No. 66-GT-96
      P. Chambadal

   h. Some Large Gas Turbine Development in the U.K. - Past, Present,
      and Future/ Paper No. 66-GT-108 - W. Rizk

2. <u>Marine</u>

   a. The Marine Gas Turbine - 1965 Status/ Paper No. 66-GT/M-26
      John W. Sawyer

   b. Gas Turbines in the Royal Navy/ Paper No. 66-GT/M-25
      Norman K. Bowers

   c. U. S. Navy's Marine Gas Turbines/ Paper No. 66-GT/M-28
      Gilman L. Graves; Maurice R. Hauschildt, William A. Brockett,
      John W. Sawyer

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(Cont'd)

2. Marine(cont'd)

d. Gas Turbine Installation Design for Naval Ships/ Paper No. 66-GT/M-34 - E. B. Good

e. A Swedish All Gas Turbine Torpedo Boat with Controllable Pitch Propellers/ Paper No. 66-GT/M-30 - Hans G. Hafstrom

f. Gas Turbine Engines in the Royal Canadian Navy Prototype Hydrofoil Vessel/ Paper No. 66-GT/M-24 - Stanley E. Hopkins

g. Marine Gas Turbine Growth in the U. S. Coast Guard/ Paper No. 66-GT/M-36 - Robert C. Case

h. Design and Development of the Orenda OT-4 Gas Turbine/ Paper No. 66-GT/M-23 - D. Quan

i. Development of the General Electric LM1500 Gas Turbine as a Marine Power Plant/ Paper No. 66-GT/M-22 - Eugene E. Stoeckly

j. Marine Developments of the Olympus Engine/ Paper No. 66-GT/M-32 B. H. Slatter

k. Pratt & Whitney Aircraft Marine Gas Turbines, Their Development and Capabilities/ Paper No. 66-GT/M-35 - G. H. Nolte

l. The Influence of Current Research and Development on the Application of the Open Cycle Gas Turbine as a Propulsion Unit for Merchant Ships/ Paper No. 66-GT/M-33 - R. W. Stuart Mitchell

m. CODAG Propulsion Machinery by Stal-Laval for Royal Danish Navy Frigates - Bo R. V. Krumlin

n. Design Considerations for Marine Gas Turbine Ducting/ Paper No. 66-GT/M-27 - William T. Sawyer, William J. Kelnhofer, and Russel A. Smith

o. An Axial Flow Reversing Gas Tubrine for Marine Propulsion/ Paper No. 66-GT/M-21 - Edward A. Butler and Roy P. Allen

p. The Development of a Marine Version of the United Aircraft of Canada PT6 Engine/ Paper No. 66-GT/M-31 - Gordon Hardy

q. U. S. Navy's Experiences in Power Generation With the Mobile Gas Turbine Paper No. 66-GT/M-29 - Conrad R. Odden

List of Technical Papers Presented
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(Cont'd)

3. Closed Cycle Gas Turbine Systems

a. Closed-Cycle Turbomachinery - Abstract/ Paper No. 66-GT/CLC-13 - Beno Sternlicht

b. The Closed-Cycle Gas Turbine for Non-Conventional Applications Paper No. 66-GT/CLC-8 - Werner Spillman

c. The Compact AK Process Nuclear System/Paper No. 66-GT/CLC-6 - Winfred M. Crim, Jr., John R. Hoffmann, and George B. Manning

d. The Application of Closed Cycle Gas Turbine System Technology to Mobile Nuclear Power Plants/ Paper No. 66-GT/CLC-3 - S. Luchter

e. Turbo Machinery Design Analysis of a 500 KW Closed Brayton Cycle Power System/ Paper No. 66-GT/CLC-15 - V. J. Smith, Winfred M. Crim, Jr., and L. F. Smith

f. The Closed Brayton Cycle for Space Power - An Assessment Paper No. 66-GT/CLC-10 - Bernard T. Resnick

g. Application of Gas Bearings to Closed-System Brayton Cycle Turbomachinery - Recent Accomplishments and Potential Problem Areas/ Paper No. 66-GT/CLC-9 - Peter W. Curwen, Henry F. Jones, and Hans Schwarz

h. Comparison of Dynamic and Static Power Conversion Systems for Undersea Missions/ Paper No. 66-GT/CLC-11 - Beno Sternlicht and J. W. Bjerklie

i. Bureau of Mines Progress in Developing the Open- and Closed-Cycle Coal-Burning Gas Turbine Power Plants/ Paper No. 66-GT/CLC-7 Jack Smith, Donald C. Strimbeck, and James P. McGee

j. The Prospects for Nuclear Reactor MHD Commercial Power Production/ Paper No. 66-GT/CLC-2 - Lawrence A. Booth

List of Technical Papers Presented
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(cont'd)

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3. Closed Cycle Gas Turbine Systems (cont'd)

   k. A Potassium-Steam Binary Vapor Cycle for a Molten-Salt Reactor Power Plant/ Paper No. 66-GT/CLC-5 - Arthur P. Fraas

   l. Two-Phase Materials Attrition Problems for Rankine Cycle Liquid Metal Power Plants/ Paper No. 66-GT/CLC-4 - Frederick G. Hammitt

   m. Design of Combustion Chambers of Heaters for Transmission of the Primary Heat of Closed Cycle Gas Turbines/ Paper No. 66-GT/CLC-1 Karl Bammert and Eberhard Nickel

   n. A Graphical Solution of the Matching Problem in Closed-Cycle Gas Turbine Plants/ Paper No. 66-GT/CLC-14 - M. H. Vavra

   o. The Development and Operating Experience of the ML-1 Mobile Nuclear Power Plants/ Paper No. 66-GT/CLC-12 - James M. Janis and Charles T. Seeley

4. General

   a. The Evolution of Compressor- and Turbine Bladings in Gas Turbine Design/ Paper No. 66-GT-106 - Claude Seippel

   b. Recent Progress in Aerodynamic Design of Axial-Flow Compressors in the United States/ Paper No. 66-GT-95 - George K. Serovy

   c. A Practical Three-Dimensional Flow Visulization Approach to the Complex Flow Characteristics in a Centrifugal Impeller/ Paper No. 66-GT-83 - Meherwan P. Boyce

   d. Thrust Augmentation/ Paper No. 66-GT-116 - William H. Heiser

   e. On a Wave Phenomenon in Turbines/ Paper No. 66-GT-99 - Jerzy A. Owczarek

   f. Perspectives for the Liquid Phase Compression Gas Turbine/ Paper No. 66-GT-111 - Gianfranco Angelino

   g. The Fundamentals of a New Screw Engine/ Paper No. 66-GT-6[illegible] - Alf Lysholm

   h. The Energy Exchanger, a New Concept for High Efficiency Gas Turbine Cycles/ Paper No. 66-GT-117 - Roger C. Weatherston and Abraham Hertzberg

List of Technical Papers Presented
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(Cont'd)

4. General (Cont'd)

i. Special Fluid Power Plants/ Paper No. 66-GT-84 - Waldemar Hryniszak M. Hutchinson, and Alexander Renton

j. Could Today's Gas Turbine Technology Benefit From New Cycle Concepts? Paper No. 66-GT-85 - Hans K. Ziebarth

k. Some Factors in High Temperature Gas Turbine Design A. H. Perugi

l. Evaluation of Heat Resistant Alloys for Marine Gas Turbine Applications Paper No. 66-GT-81 - L. J. Fiedler and Regis M. N. Pelloux

m. Problems Associated with the Burning of Heavy Fuel Oil in an Open Cycle Gas Turbine/ Hans H. Franzke

5. Jet Expanders

a. Gas Turbine Applications by General Electricity Generating Board/ Paper No. 66-GT-115 - L. C. L. Dale and William F. Cusworth

b. Multipurpose Use of Aircraft Jet Expander Power Packs in Puerto Rico/ Paper No. 66-GT-94 - Julio Negroni

c. Five Years' Experience With Aircraft Gas Turbines in Industrial Applications/ Paper No. 66-GT-105 - William J. Closs

6. Combined Cycle Symposium

a. Trends in Combined Steam-Gas Turbine Power Plants in the USA. Paper No. 66-GT/CMC-67 - Richard W. Foster-Pegg

b. A Medium-Size Combined Cycle Power Station/ Paper No. 66-GT/CMC-69 Warren M. Sybert

c. Gasteam - A Combination of Gas and Steam Turbines/ Paper No. 66-GT/CMC-70. Lars Elmenius

d. Advanced Gas Turbines for Combined Cycle Power Plants/ Paper No. 66-GT/CMC-71 - James O. Stephens and Paul L. Berman

e. Evaluating Systems to Increase Gas Turbine Capability/ Paper No. 66-GT/CMC-65 - Thomas G. Hiniker and W. B. Wilson

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(Cont'd)

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6. Combined Cycle Symposium (Cont'd)

   f. Application of Free-Piston Gasifiers in Plants Using Combined Gas- and Steam-Cycles/ Paper No. 66-GT/CMC-66 - P. Szereszewski

   g. Gas Turbine With Utilization of Exhaust Heat for District Heating Paper No. 66-GT/CMC-61 - Otto Schmoch

   h. Gas Turbines and Waste Heat Boilers/ Paper No. 66-GT/CMC-62 Nicolo Mancuso

   i. Expanders in Chemical and Physical Processes/ Paper No. 66-GT/CMC-64 R. Schmid

   j. Steam Generators for Combined Steam and Gas Turbine Plants/ Paper No. 66-GT/CMC-63 - Rodolphe J. Ecabert

   k. The Supercharged Steam Generator - Soem Aspects of Design and Pressure Level Selection/ Paper No. 66-GT/CMC-68 - W. P. Gorzegno

7. Metallurgy

   a. Influence of Microstructure and Heat Treatment on Impact and Creep Properties of a Low Alloy CR-Mo-V Turbine Steel/ Paper No. 66-GT-112 Krister Relander

   b. Metallurgical Considerations Involved in the Development of Nickel-Base High Temperature Sheet Alloys/ Paper No. 66-GT-104 - Edward G. Richards

   c. The Effect of Vacuum Arc Remelting of Airmelt Electrodes on the Structure and Elevated Termperature Properties of a Nickel Base Gas Turbine Superalloy/ Paper No. 66-GT-113 - Frank M. Richmond

   d. Increasing Strength of Gas Turbine Alloys by Cold Work Prior to Aging/ Paper No. 66-GT-102 - Frank M. Richmond

8. Special Equipment

   a. Design and Performance Characteristics of Over-Running Clutches in Gas Turbine Drive Applications/ Paper No. 66-GT-92 - Roger L. Daniels

   b. Electric Hydraulic Governor Control for Industrial and Commercial Gas Turbine Use/ Paper No. 66-GT-118 - Norman G. Aivis

   c. Operating and Control Characteristics of a Large Compound Cycle - Two Shaft Gas Turbine/ Paper No. 66-GT-101 - Alfredo Congiu

List of Technical Papers Presented
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(Cont'd)

8. Special Equipment (co-t'd)

d. The Single-Blow Transient Testing Technique for Compact Heat Exchanger Surfaces/ Paper No. 66-GT-93 - Charles P. Howard

e. The Development of a Glass-Ceramic Axial Flow Rotary Regenerator/ Paper No. 66-GT-107 - John G. Lanning and David J. S. Wardale

f. Air Filter Application on Gas Turbines/ Paper No. 66-GT-114 T. Ernst

g. Air Filtration for the Gas Turbine/ Paper No. 66-GT-119 Hugo Giannotti

9. Small Gas Turbines

a. Problems Related to the Development of a Gas Turbine in the 10-30 HP Class/ Paper No. 66-GT-87 - Ulrick Oprecht

b. The Split Compressor Differential Gas Turbine Engine for Vehicle Propulsion/ Paper No. 66-GT-82 - C.N. Doyle and Terence S. Wilkinson

c. Military Potential of the Small Gas Turbine/ Paper No. 66-GT -91 Donald D. Weidhuner

d. Small Gas Turbines in Industrial Applications/ Paper No. 66-GT-110 Paul A. Pitt

e. Prewhirl an Added Degree of Freedom to the Designer of Small Single Shaft Gas Turbines/ Paper No. 66-GT-89 - A. R. Shouman

f. Whither Go the Small Gas Turbines?/ Paper No. 66-GT-90 Werner T. Von Der Nuell

10. Noise Symposium

a. Aerodynamic Noise in Turbomachinery - Allan Powell

b. Axial-Compressor Noise: Some Results from Aero-Engine Research Christopher L. Morfey

c. The Mechanisms of Noise Generation in a Compressor Model/ Paper No. 66-GT/N-42 - Bruce T. Hulse

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(cont'd)

10. Noise Symposium (cont'd)

d. Internally Generated Noise From Gas Turbine Engines. Measurement and Prediction/ Paper No. 66-GR/N-43 - M. J. T. Smith

e. Facilities and Instrumentation for Aircraft Engine Noise Studies Paper No. 66-GT/N-41 - Robert E. Gorton

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13. ABSTRACT

Complete list of technical papers presented during the ASME 11th Annual Gas Turbine Conference, Zurich, Switzerland, 14 - 17 March 1966. The report includes a summary of certain selected papers.

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
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INSTRUCTIONS

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